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Allaire et al.

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(54) **ALTERNATOR DISCONNECTOR CIRCUIT-BREAKER BY A SERVOMOTOR**

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H01H 33/14 (2006.01)

(52) **U.S. Cl.** **218/2**; 218/7; 218/153

(58) **Field of Classification Search** 218/1–14, 218/44, 58, 67–71, 78–80, 84, 119, 120, 218/140, 152–154

See application file for complete search history.

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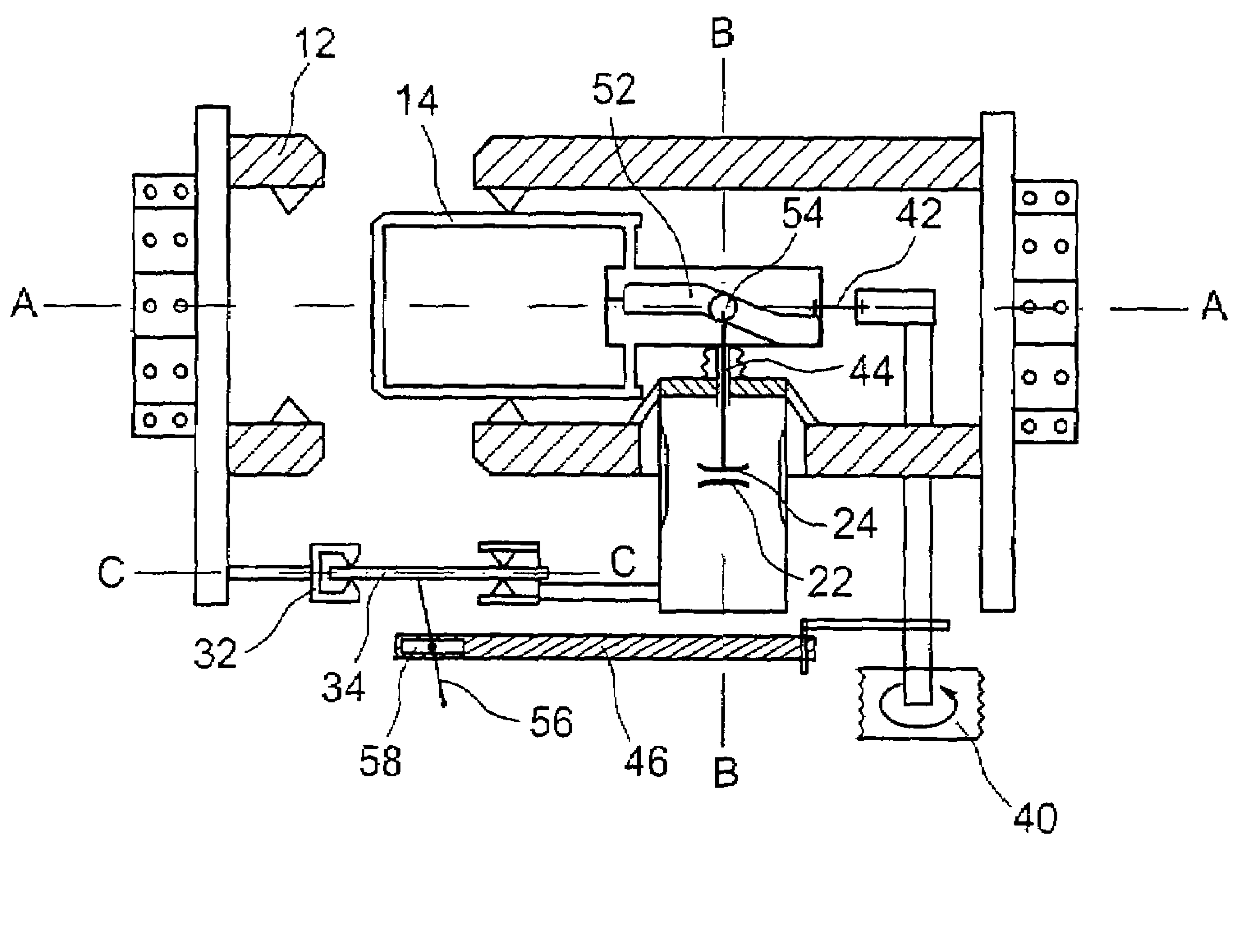
(57) **ABSTRACT**

A first switch (**10**) has a first pair of contacts (**12**, **14**) that are mounted to move relative to each other in translation. A circuit-breaker second switch (**20**) has a second pair of contacts (**21**, **24**) that are mounted to move relative to each other in translation, the second switch (**20**) being put in parallel with the first switch (**10**). A disconnector third switch (**30**) has a third pair of contacts (**32**, **34**) that are mounted to move relative to each other. Synchronization means (**50**, **50'**) make it possible, while breaking is taking place, for the contacts of the first switch (**10**) to separate before the contacts of the second switch (**20**) separate, the contacts of the second switch themselves separating before the third contacts (**32**, **34**) separate fully. The synchronization means are actuated by a servomotor (**40**).

12 Claims, 4 Drawing Sheets



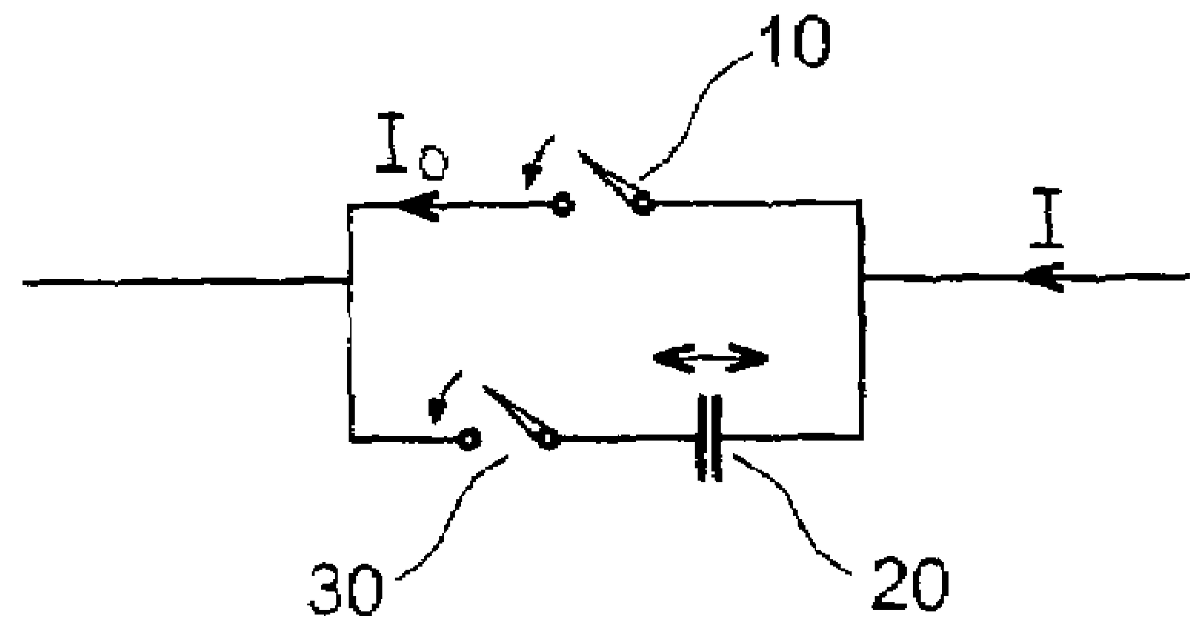


FIG. 1

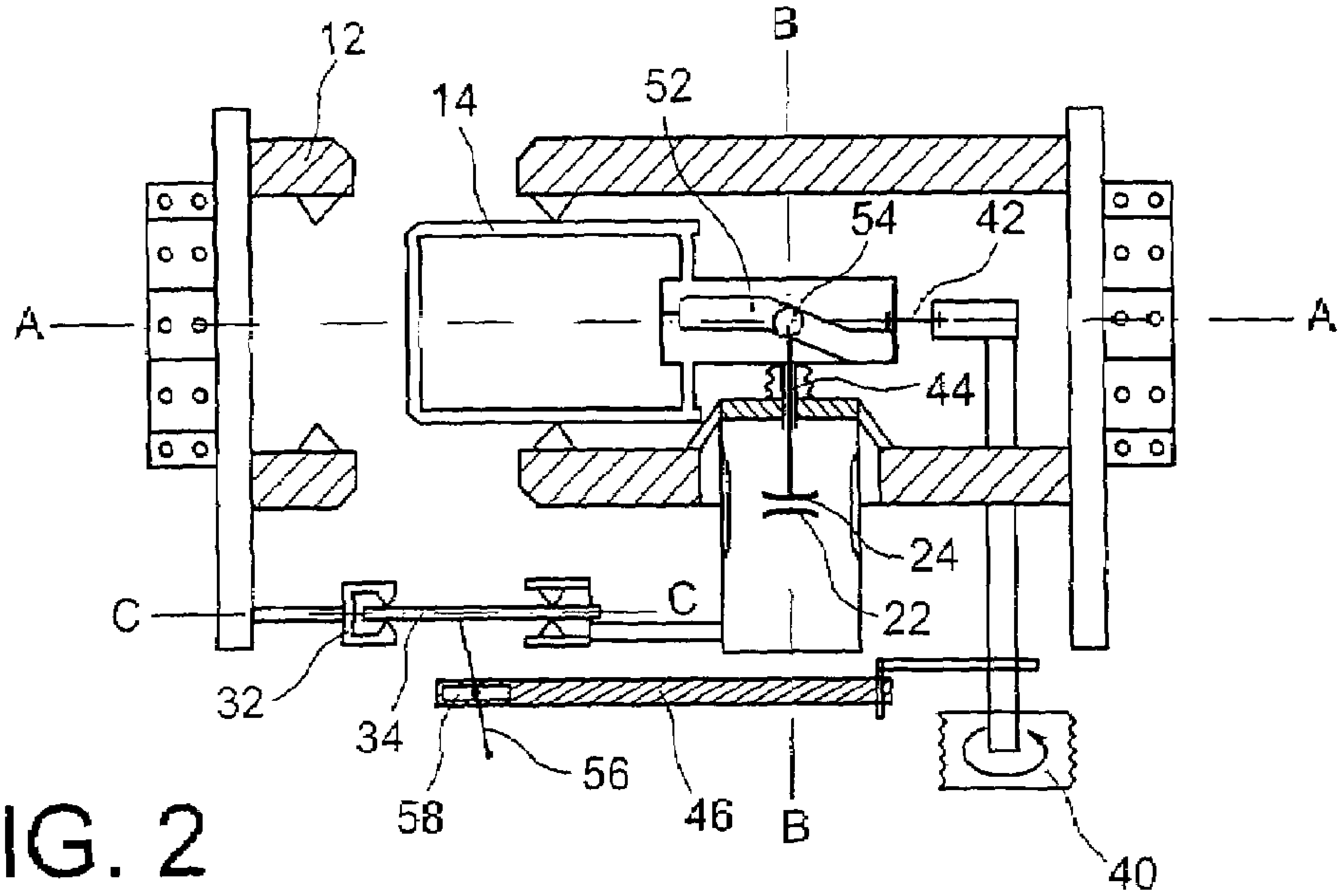


FIG. 2

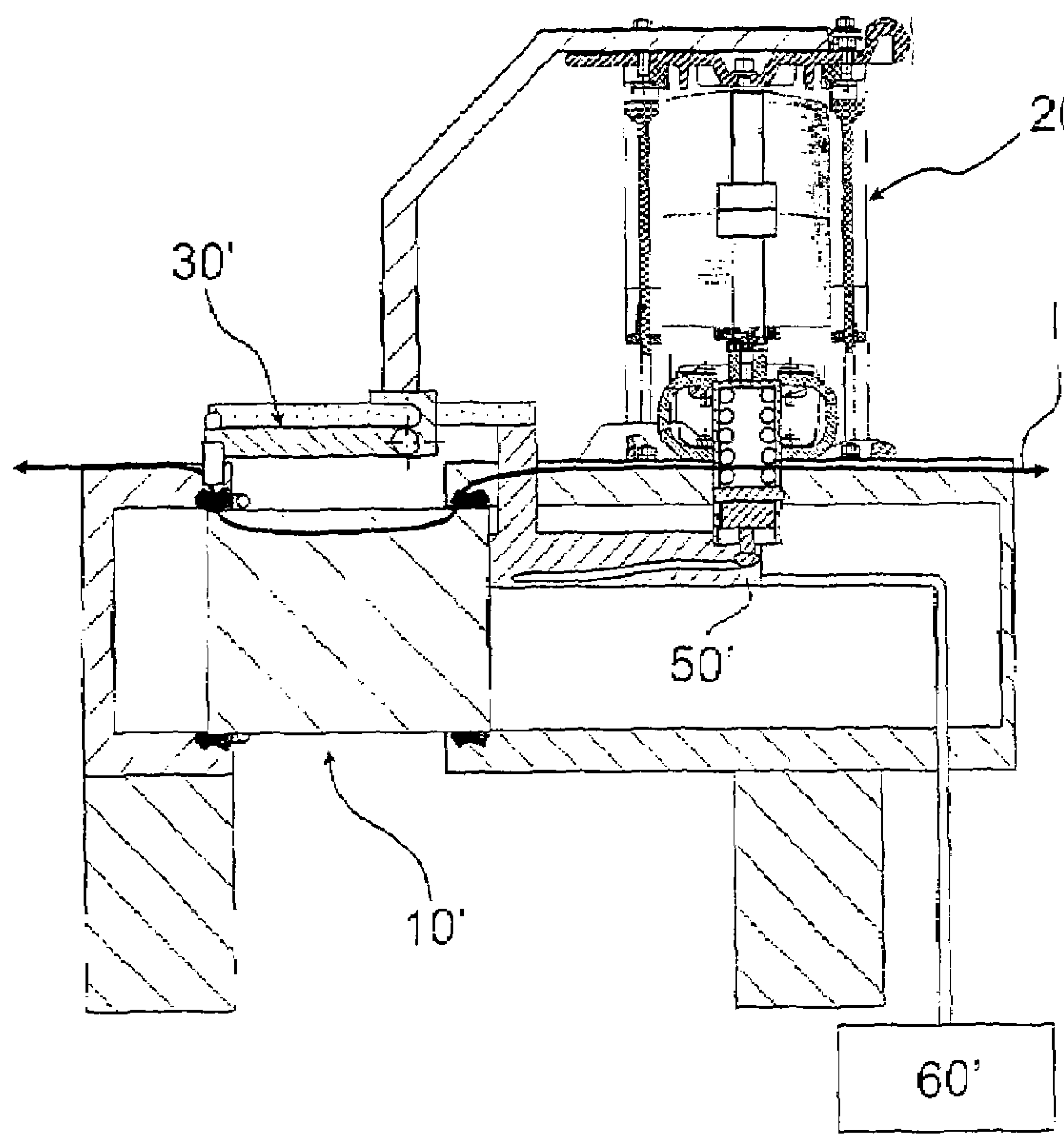


FIG. 3A

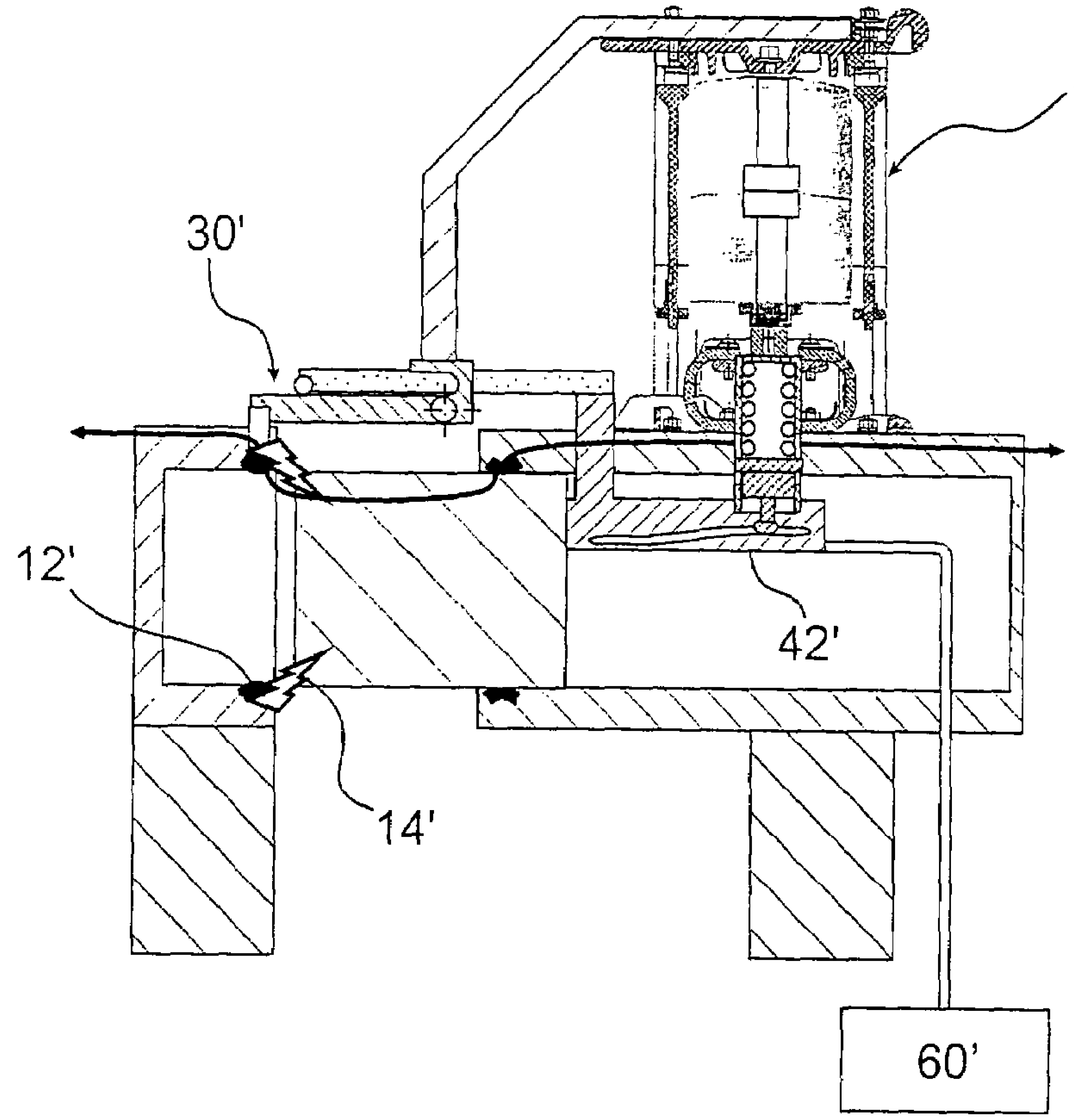


FIG. 3B

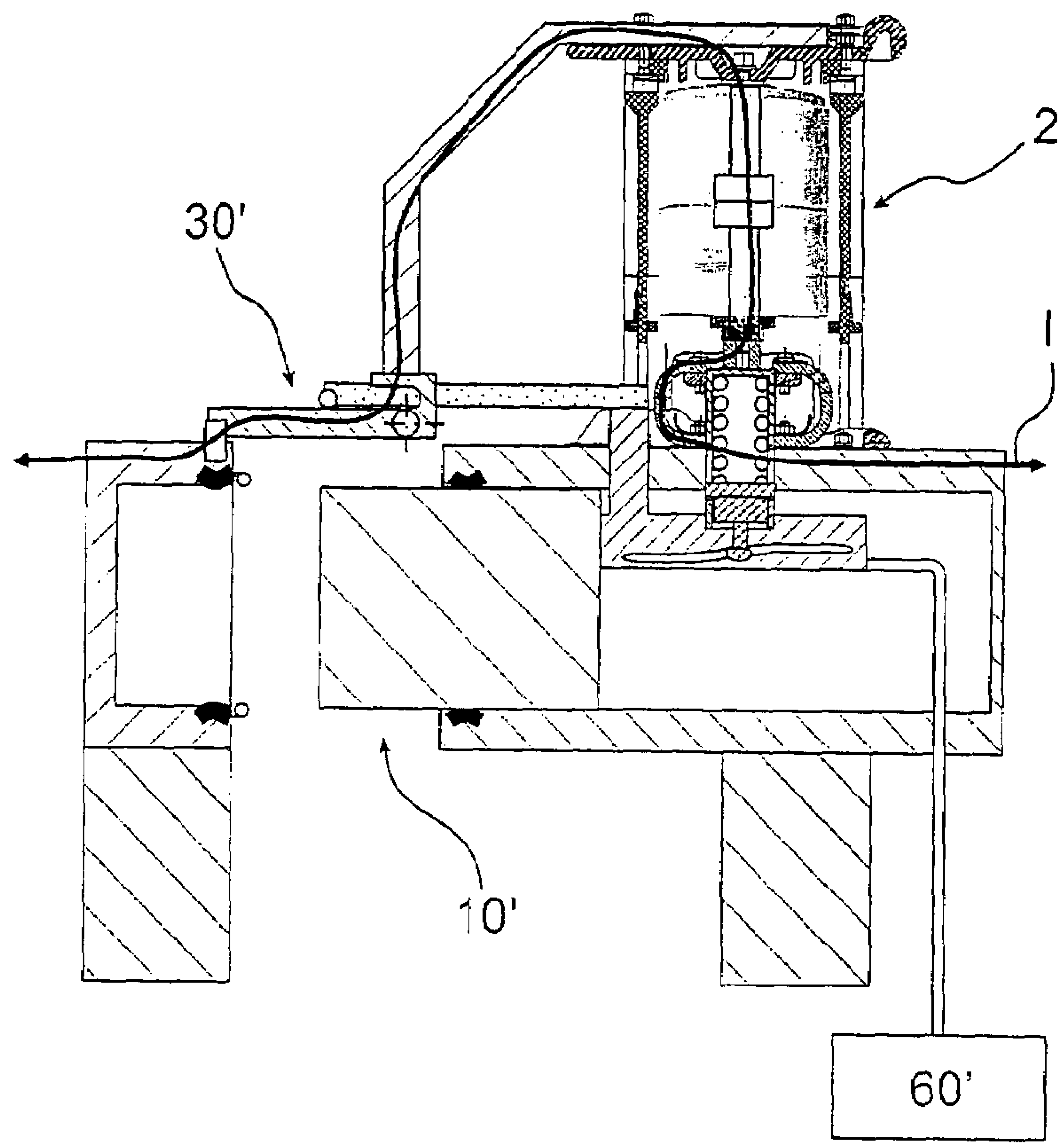


FIG. 3C

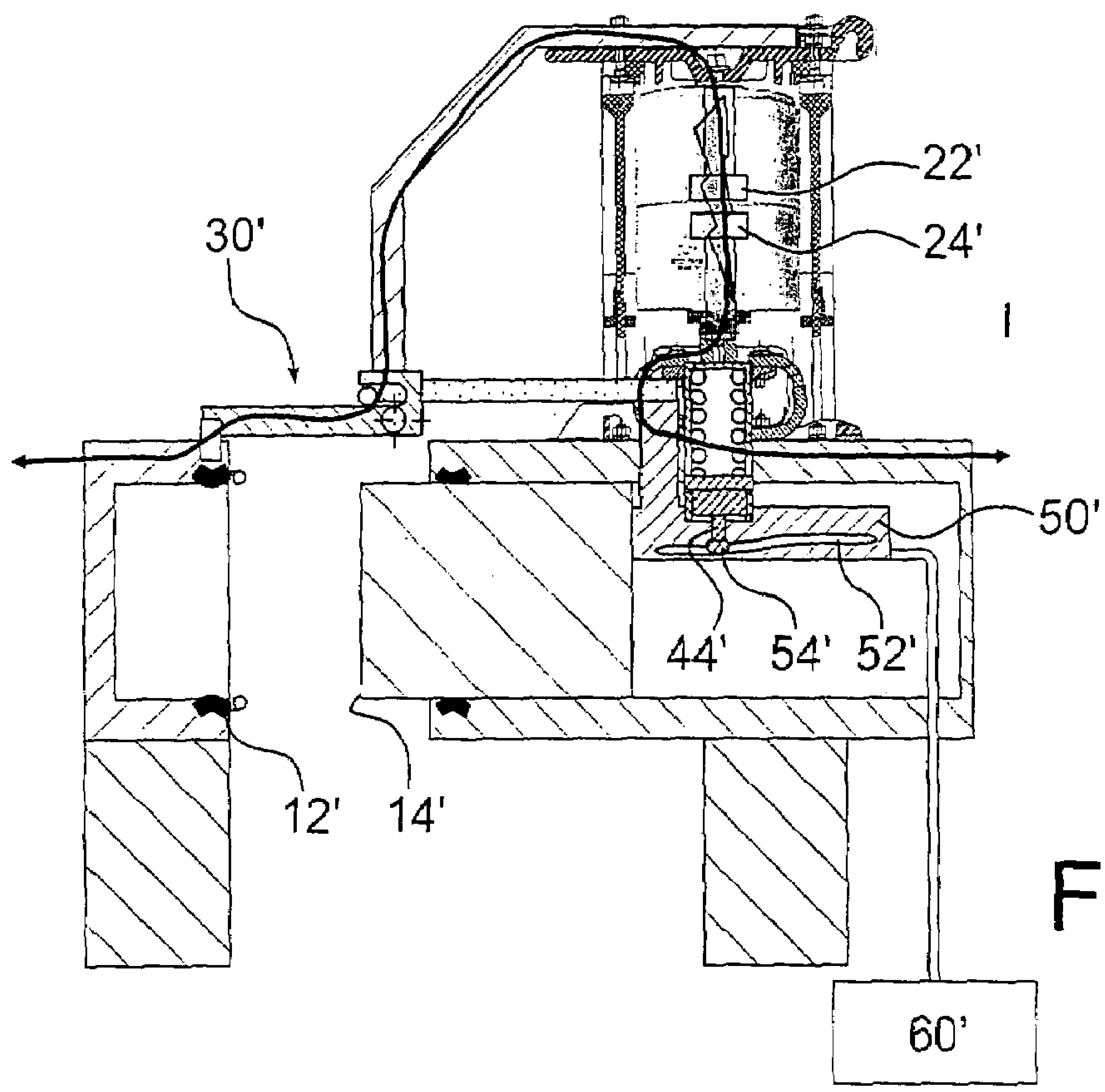


FIG. 3D

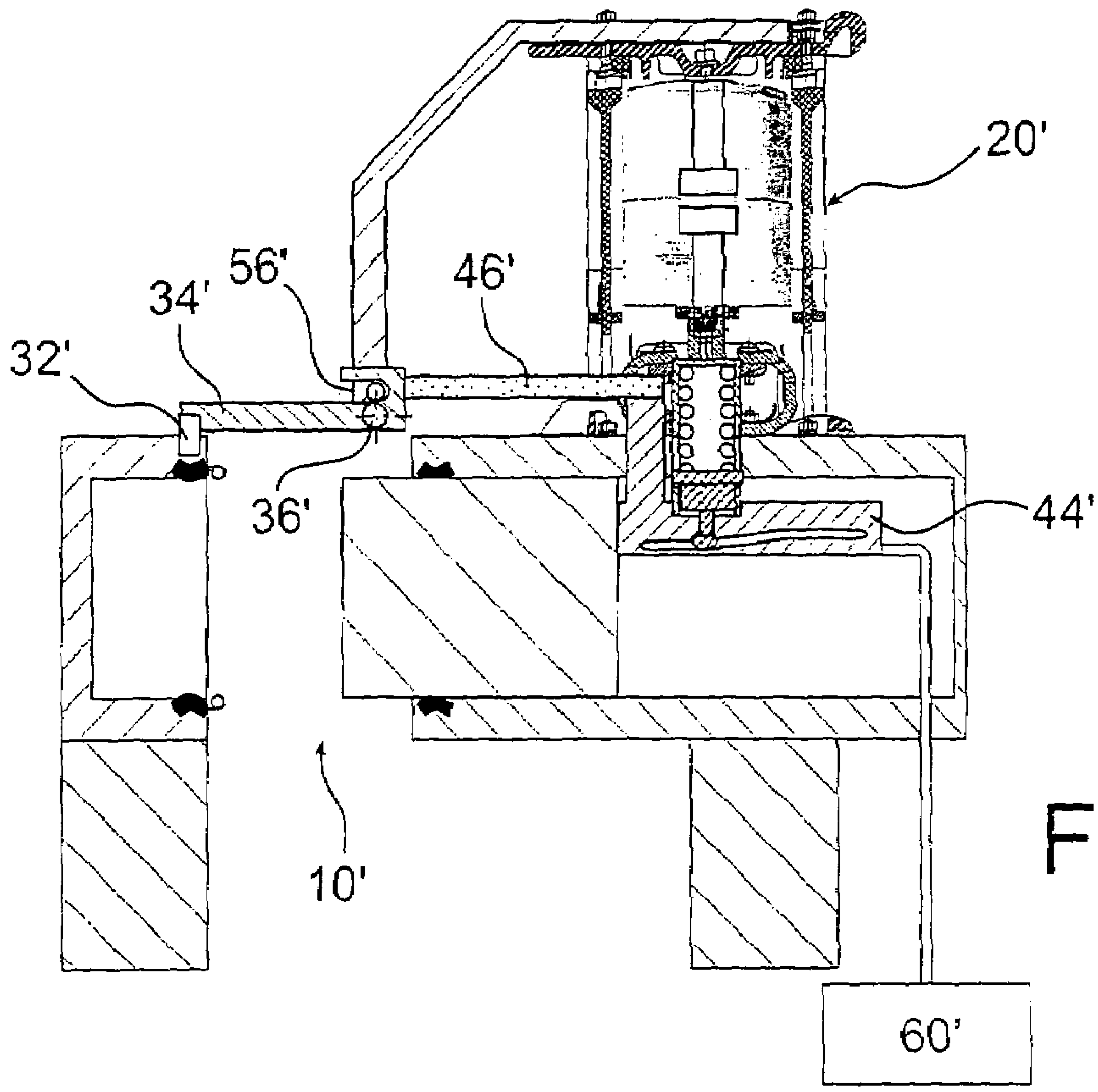
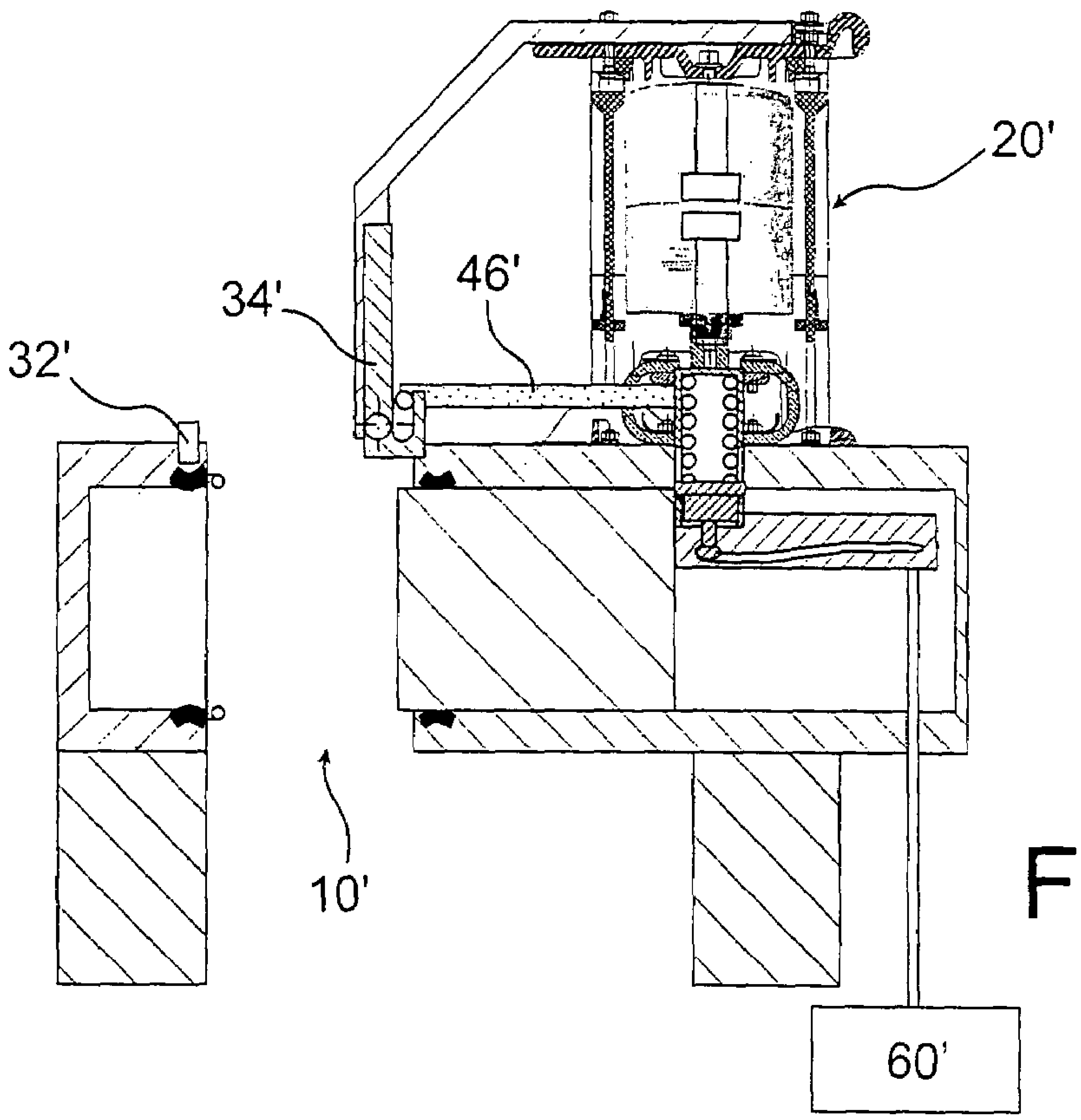
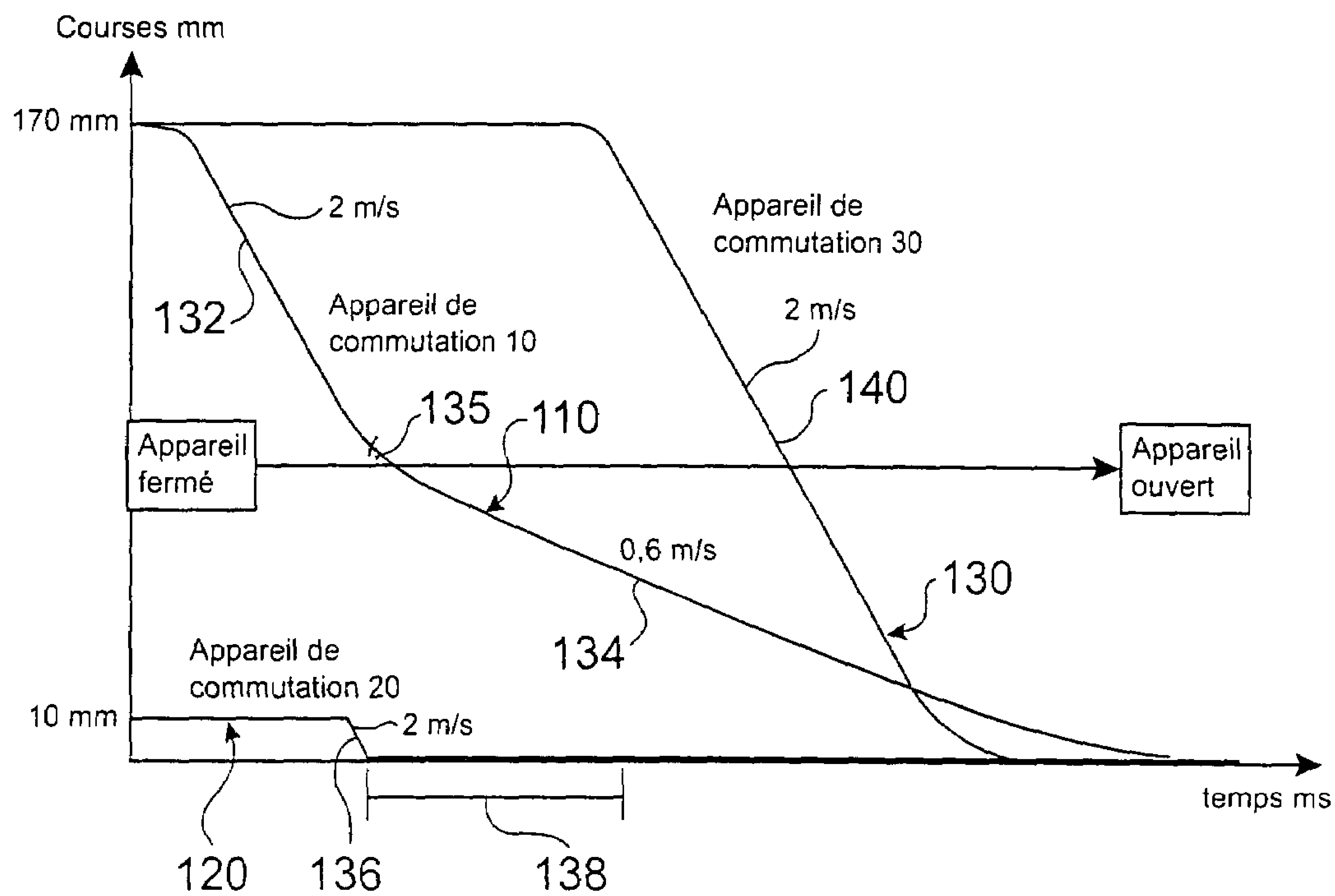


FIG. 3E



20'
46'
34'
32'
10'
60'

FIG. 3F



Courses mm
170 mm
2 m/s
132
Appareil de
commutation 10
Appareil de
commutation 30
2 m/s
140
135
110
Appareil
fermé
Appareil
ouvert
0,6 m/s
130
134
Appareil de
commutation 20
10 mm
2 m/s
temps ms
120
136
138

FIG. 4

ALTERNATOR DISCONNECTOR CIRCUIT-BREAKER BY A SERVOMOTOR

CROSS-REFERENCE TO RELATED PATENT APPLICATION OR PRIORITY CLAIM

This application claims the benefit of a French Patent Application No. 06-51709, filed on May 12, 2006, in the French Intellectual Property Office, the disclosure of which is incorporated herein in its entirety by reference.

BACKGROUND

Field of the Invention

The invention relates to an alternator disconnector circuit-breaker comprising:

- a first switch having a first pair of contacts that are mounted to move relative to each other in translation along a first axis;
- a circuit-breaker second switch having a second pair of contacts that are mounted to move relative to each other in translation along a second axis, the second switch being put in parallel with the first switch;
- a disconnector third switch having a third pair of contacts that are mounted to move relative to each other; and
- synchronization means making it possible, while breaking is taking place, for the contacts of the first switch to separate before the contacts of the second switch separate, the contacts of the second switch themselves separating before the third contacts separate fully;

Switchgear of this type is already known (EP 0 877 405, EP 0 878 817). Such switchgear is driven by a single control means connected to the pole by a linkage serving to guarantee that the circuit-breaker is driven in the proper operating sequence. However, a combined control means and a linkage capable of opening a main circuit, a circuit-breaker, and then a disconnector, and then of actuating a position indicator, is very difficult to design because of the contradiction between the requirements for the movements of each of the items of equipment and the time taken by the movements of conventional control means for controlling circuit-breakers. That actuating sequence is also made complex by the combination of geometrical and of time constraints.

It is also known (EP 1 108 261) that a servomotor can be used for actuating a circuit-breaker. However, such a servomotor is not used for driving a plurality of items of switchgear via a common linkage.

OVERVIEW

An object of the present invention is to provide an alternator disconnector circuit-breaker that remedies those drawbacks. This object is achieved by the fact that the synchronization means are actuated by a servomotor.

By means of this characteristic, it is possible to control the movement characteristics of the contacts as a function of time by an electronic method. This makes it possible to adjust the control energy to match exactly the needs of the movement to be achieved.

Advantageously, the servomotor actuates the synchronization means in a manner such as to obtain an opening speed at which the contacts of the first switch open that lies in the range 1.5 meters per second (m/s) to 2.5 m/s for about the first half of the opening stroke of said contacts and an opening

speed at which said contacts open that lies in the range 0.5 m/s to 0.8 m/s for the second half of the opening stroke of said contacts.

By means of this characteristic, a fast movement is generated at the beginning of the cycle that slows down sharply in a portion of the cycle so as to wait for the arc to be extinguished and for the disconnector to move.

Preferably, the synchronization means are designed in a manner such that the second switch opens when the first switch has traveled along substantially one half of its stroke at an opening speed lying in the range 1.5 m/s to 2.5 m/s.

Preferably, the third switch opens once the first switch has traveled along substantially two-thirds of its opening stroke. Advantageously, the synchronization means are designed in a manner such that the opening speed of the third switch lies in the range 1.5 m/s to 2.5 m/s.

Optional or alternative additional characteristics are listed below:

- the contacts of the third pair of the third switch are mounted to move relative to each other in translation along a third axis, at least one of the second and third axes intersecting the first axis;
- the third axis is substantially parallel to the first axis;
- the second axis intersects the first axis;
- the contacts of the third pair are mounted to move relative to each other by pivoting about an axis;
- the third switch is in series with the second switch and the second and third switches together are in parallel with the first switch;
- the second axis forms an angle that is substantially equal to 90° relative to the first axis;
- each pair of contacts is associated with an actuator bar that is mounted to move under action from control means; and
- the circuit-breaker has synchronization means adapted to separate the contacts of the first switch, then the contacts of the second switch, and then the contacts of the third switch, in that order.

BRIEF DESCRIPTION OF DRAWINGS

Other characteristics and advantages of the present invention will also appear on reading the following description of embodiments given by way of illustration and with reference to the accompanying drawings. In the drawings:

FIG. **1** diagrammatically shows the circuit-breaking principle of a disconnector circuit-breaker of the invention;

FIG. **2** shows a preferred embodiment of the circuit-breaker of the invention;

FIGS. **3**A to **3**F show a circuit-breaking sequence for another embodiment of an alternator circuit-breaker of the invention; and

FIG. **4** shows three curves that represent the strokes of the three switches as a function of time.

DESCRIPTION OF EXAMPLE EMBODIMENTS

The operating principle of a circuit-breaker, and in particular of an alternator circuit-breaker of the invention, is shown diagrammatically in FIG. **1**, with a main circuit in which a current I_0 close to the rated current I flows when in operation, and an auxiliary circuit that is used for breaking a short-circuit.

For an alternator circuit-breaker, passing a current I of rated magnitude greater than a few thousand amps requires a switch **10** whose contacts are particularly conductive, e.g. made of copper, to be used on the main circuit; the breaking power of those contacts is, however, limited due to electric arcs striking. A circuit-breaker second switch **20** is put in parallel with the first switch **10** in order to perform the circuit-breaking function proper. The first switch **10** opening causes, de facto, the current I to be switched over from the main circuit to the auxiliary circuit; the contacts of said second switch **20** that are, for example, made of tungsten, are of limited performance as regards passing the rated current I, but have high breaking power.

Thus, the functions of passing the permanent current and of breaking short-circuit current are separated: when such circuit-breaking is necessary, firstly the first switch **10** is activated, all of the current I then going over to the auxiliary circuit and causing the second switch **20** to be opened so as to obtain the circuit-breaking function. In addition, a third switch **30** is then opened: its function is mainly a safety function, its association on the auxiliary circuit making it possible to avoid a reduction in the dielectric strength of the second switch **20** that might accidentally allow current to pass into the associated branch.

In order to re-close such a circuit-breaker, the reverse order applies: firstly the disconnector **30** is re-closed, then the circuit-breaker switch **20** is re-closed, and finally the first switch **10** is re-closed.

Each of the switches **10**, **20**, **30** has a pair of contacts that are mounted to move relative to each other; advantageously, the first contact **12**, **22**, **32** of each pair is stationary, and the second contact **14**, **24**, **34** is a moving contact that is mounted to move relative to the first contact. In a first embodiment show in FIG. **2**, each of the moving contacts moves in translation along a respective axis AA, BB, CC.

In particular, the first switch **10** can be of the gas-insulated type; it can also, if the rated current is very high, itself be an item of switchgear comprising two switches put in parallel with each other. Preferably, however, as shown, the first switch **10** is an air-insulated switch having a tubular first contact **12** into which a second contact **14** that is also tubular can be inserted.

The second switch **20** can be a gas-insulated circuit-breaker containing a gas of the sulfur hexafluoride (SF_6) type; preferably, since the current $I-I_0$ passing through it is low under normal operating conditions, it is a vacuum "bottle": this reduces costs and makes it possible to avoid using SF_6, which does not satisfy all ecological criteria. The moving contact **24** of the second switch **20** is moved by means of an actuator bar **44** mounted to move along the axis BB.

Finally, the third switch **30** can, in one embodiment, have a stationary contact **32** into which another moving contact **34** of the rod type can be inserted along the opening/closure axis CC. The rod **34** can be moved via a bar **46** in translation.

A servomotor **40** makes it possible to move the first, second, and third moving contacts **14**, **24**, and **34**. To this end, the servomotor **40** is connected functionally to each of the actuators **42**, **44**, **46**. Synchronization means **50** make it possible to defer the relative openings of the switches **10**, **20**, **30**.

The servomotor **40** opens the first switch **10** first. This opening takes place, in a first portion of the opening stroke of the contacts at a relatively high speed, lying in the range 1.5 m/s to 2.5 m/s, and preferably equal to 2 m/s. The first portion extends over substantially one half of the opening stroke of the first switch **10**.

Once the first switch has reached a sufficient opening distance, the synchronization means **50** cause the second switch **20** to open. Said sufficient distance is a function of voltage. By way of example, an opening distance of 70 millimeters (mm) can be sufficient for a voltage of 61 kilovolts (kV). In any event, the second switch opens at the latest once the first switch has traveled along one half of its stroke. For example, if the stroke of the first switch is 170 mm, the second switch opens at the latest once the moving contacts of the first switch have traveled 85 mm. Its opening speed is relatively fast, and is about 2 m/s.

Once the first switch has traveled along one half of its stroke, the servomotor slows down its speed of actuation of the synchronization mechanism **50** so that the second half of the opening of the contacts **12**, **14** takes place relatively slowly. The expression "relatively slowly" should be understood to mean that the opening speed, expressed in m/s is about three times slower than the relatively fast speed. Thus, the relatively slow opening speed of the first switch lies in the range 0.5 m/s to 0.8 m/s.

Once the circuit-breaker **20** is open, the synchronization means act to guarantee that a certain waiting time necessary for extinguishing the arc of the circuit-breaker **20** elapses before the third contact **34** of the disconnector **30** is moved. Once the disconnector has reached a sufficient disconnection distance, the servomotor moves a position indicator (not shown) whose function is to indicate whether the circuit-breaker is open or closed.

Although each actuator bar **42**, **44**, **46** of this embodiment moves in translation and is secured to the same control means **40**, the three opening/closure axes AA, BB, CC are not necessarily parallel, at least one of them intersecting the first axis AA, for example. For reasons of compactness, it is preferable to dispose at least one axis BB at an angle of about 90° relative to the first axis AA. Although this configuration requires different arrangements of the pairs of contacts **12**, **14**; **22**, **24**; **32**, **34** and of the means **42**, **44**, **46** for moving them, it appears that this configuration, which is a priori dismissed for reasons of complexity of the synchronization, can be chosen.

For example, the synchronization means **50** can thus comprise a groove **52** in the actuator bar **42** of the first switch **10**, which groove is generally longitudinal along the axis AA of the bar but has a slanting portion, the groove being associated with an element of the lug **54** type integral with the second actuator bar **44**, so that, in a first stage, while the first moving contact **14** is moving, the position of the lug **54** is moved so as to move the second moving contact **24** away from the second stationary contact **22**.

It can be advantageous for the axes AA, CC of the change-over switch **10** and of the disconnector **30** to be parallel, as shown in FIG. **2**, but other options are possible, as described below. The synchronization means **50** can have a system similar to the preceding system **52**, **54** for deferring opening of the disconnector **30** relative to opening of the circuit-breaker switch **20**; it is however preferable for the synchronization means **50** to be associated directly between the first and the third switches **10**, **30**. For example, the synchronization means **50** comprise a lever arm **56** coupled at an end portion to the third moving contact **34** and whose pivot axis is associated with a groove **58** located in the actuator bar **46** of the third switch **30**: the actuator bars **42**, **46** of the first and third switches **10**, **30** are moved jointly by the actuator means **40**, but a delay in moving the third contact **34** is generated by the latency before the lever **56** pivots.

Other actuation and synchronization solutions are naturally imaginable.

In particular, as shown in FIG. **3**, the disconnector switch **30'** can operate on another principle of the "knife-switch" type. In the alternator circuit-breaker shown, the main switch **10'** has two contacts **12'**, **14'** that are mounted to move relative to each other in translation, and that are disposed in a casing such as a tube that is 200 mm in diameter; in an operating position shown in FIG. 3A, the alternator current I_0 flows through this main circuit (see arrow).

When circuit-breaking is required, the servomotor **60** separates two contacts **12'**, **14'** relatively rapidly: actuation is effected by means of a bar **42'**. In a first stage shown in FIG. 3B, the current I continues to flow along its main path, but an arc strikes across the distance between the two contacts **12'**, **14'** of the switch **10'**; then the circuit-breaking on the main circuit is completed (FIG. 3C), and the current flows through the auxiliary circuit only, the delay means **50'** having deferred opening of the contacts **22'**, **24'** of the circuit-breaker switch **20'**. For example, the dielectric distance on the main circuit makes it possible to withstand the transient re-strike voltage, i.e. the actuator bar **42'** moves over about one half of its total stroke before the vacuum chamber **20'** opens.

In order to break the short-circuit current, the servomotor **60'** moves in translation the two relatively movable contacts **22'**, **24'** of the circuit-breaking chamber **20'** along an axis orthogonal to the translation axis of the first switch **10'**: FIG. 3D. The two contacts **22'**, **24'** are moved by means of an actuator bar **44'** that is orthogonal to the bar **42'**, and that is secured thereto via delay means **50'**, e.g. by means of a lug **54'** moving in a groove **52'** in the first actuator bar **42'**. While the contacts **22'**, **24'** are moving apart, an arc strikes, and then, very rapidly, circuit-breaking is completed: FIG. 3E.

During these stages, and by means of the delay means **50'**, the disconnector switch **30'** is not actuated. From this point, the servomotor **60'** drives the contacts relatively slowly. The stationary contact **32'** of the disconnector **30'** is secured to the stationary contact **12'** of the first switch; the second contact **34'** of the disconnector **30'** is mounted to move relative to the stationary contact by pivoting about an axis **36'**. The actuator means **46'** for actuating the contacts **32'**, **34'** of said switch **30'** are secured to the first bar **42'**; in addition, at the pivot **36'**, the moving contact **34'** is provided with delay means **56'** in the form of a groove that is complementary to a lug on the actuating bar **46'**, but that enables the lug to move relative thereto before the contact **34'** is driven by the bar **46'** in rotation about its axis **36'**; finally, as shown in FIG. 3F, the disconnection is completed.

Naturally, other actuations are possible: for example, the disconnector **30'** can also move in a "horizontal" plane, i.e. in the context shown, by pivoting about an axis **36'** that is parallel to one of the translation axes of the contacts of the other two switches **10'**, **20'**.

In FIG. **4**, reference **110** identifies the curve of the opening stroke of the first contact **10**, reference **120** identifies the opening stroke of the second switch **20**, and reference **130** identifies the opening curve of the third switch **30**. As can be observed, curve **110** presents a portion **132** of steep gradient, and a portion **134** of relatively shallower gradient. Portion **132** corresponds to that portion of the cycle during which the servomotor **40** or **60'** actuates the synchronization means relatively rapidly, and the portion **134** corresponds to the second portion of the opening cycle of the disconnector circuit-breaker during which portion the servomotor actuates the same synchronization means relatively slowly. By way of example, the portion **132** of the curve **110** corresponds to an opening speed of 2 m/s, whereas the portion **134** of the same curve corresponds to an opening speed of 0.6 m/s. In other words, the opening speed is more than three times higher during the relatively fast portion of the opening cycle than during the relatively slow opening portion. The point **135** of transition between the two portions of the curve is situated substantially half way along the opening stroke of the first switch **10**. As can be seen in FIG. **4**, the circuit-breaker switch **20** opens substantially at the end of the fast opening period and the gradient of the portion **136** is substantially equal to the gradient of the portion **132**, i.e. it corresponds to a speed of approximately 2 m/s, in the example. After the end of the opening of the circuit-breaker switch **20**, a certain waiting time elapses, e.g. about ten milliseconds (ms) as shown by the straight-line segment **138** before the disconnector third switch **30** opens. At this point, the first switch has traveled along substantially two-thirds of its opening stroke. The disconnector switch **30** then opens relatively rapidly, as shown by the gradient **140** of the curve **120**, i.e. at a speed of about 2 m/s, even though, at that time, the servomotor is actuating opening of the first contact relatively slowly. The relatively fast opening of the third switch is obtained by the construction of the synchronization means, e.g. by the ratio of the lever arms **42** and **56** (see FIG. **2**).

What is claimed is:

1. An alternator disconnector circuit-breaker comprising:

a first switch having a first pair of contacts that are mounted to move relative to each other in translation along a first axis;

a circuit-breaker second switch having a second pair of contacts that are mounted to move relative to each other in translation along a second axis, the second switch electrically connected in parallel with the first switch;

a disconnector third switch having a third pair of contacts that are mounted to move relative to each other; and

synchronization means making contacts of the first switch to separate before the contacts of the second switch separate, wherein the contacts of the second switch separate before the third contacts separate fully;

said alternator disconnector circuit-breaker being characterized in that the synchronization means are actuated by a servomotor which actuates the synchronization means to obtain a first opening speed at which the first pair of contacts begin to separate around a first half of an opening stroke, the servomotor and the synchronization means to obtain a second opening speed at which the first pair of contacts continue to open around a second half of the opening stroke, wherein the first opening speed is approximately three times greater than the second opening speed.

2. A circuit-breaker according to claim **1**, characterized in that the servomotor actuates the synchronization means in a manner such as to obtain an opening speed at which the contacts of the first switch open that lies in the range 1.5 m/s to 2.5 m/s for about the first half of the opening stroke of said contacts and an opening speed at which said contacts open that lies in the range 0.5 m/s to 0.8 m/s for the second half of the opening stroke of said contacts.

3. A circuit-breaker according to claim **2**, characterized in that the synchronization means are designed in a manner such that the second switch opens when the first switch has traveled along substantially one half of its stroke at an opening speed lying in the range 1.5 m/s to 2.5 m/s.

4. A circuit-breaker according to claim **2**, characterized in that the third switch opens once the first switch has traveled along substantially two-thirds of its opening stroke.

5. A circuit-breaker according to claim **4**, characterized in that the synchronization means are designed in a manner such that the opening speed of the third switch lies in the range 1.5 m/s to 2.5 m/s.

6. A circuit-breaker according to claim **1**, characterized in that the contacts of the third pair of the third switch are mounted to move relative to each other in translation along a third axis, at least one of the second and third axes intersecting the first axis.

7. A circuit-breaker according to claim **6**, in which the third axis is substantially parallel to the first axis.

8. A circuit-breaker according to claim **1**, characterized in that the contacts of the third switch are mounted to move relative to each other by pivoting about an axis.

9. A circuit-breaker according to claim **1**, characterized in that the third switch is in series with the second switch and the second and third switches together are in parallel with the first switch.

10. A circuit-breaker according to claim **1**, characterized in that the second axis forms an angle that is substantially equal to 90° relative to the first axis.

11. A circuit-breaker according to claim **1**, characterized in that each pair of contacts is associated with an actuator bar that is mounted to move under action from control means.

12. A circuit-breaker according to claim **1**, characterized in that the synchronization means are adapted to re-close the contacts of the switches successively in the reverse order relative to the order in which they are separated.

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